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QUASI-STATIC CRACK PROPAGATION IN CONCRETE WITH COHESIVE ELEMENTS UNDER MIXED-MODE CONDITIONS

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ABSTRACT

The behaviour of concrete is very complex due to its heterogeneity, anisotropy, nonlinearity and localization of deformation in the form of cracks (failure mode I) or shear zones (failure mode II). An understanding of the mechanism of the formation of strain localization is very important, since it acts as a precursor to the ultimate fracture and failure.

The paper deals with propagation of cracks in concrete specimens under mixed mode conditions. The calculations were carried out with different constitutive models. First, the material was modelled with two isotropic continuum crack models: an elasto-plastic and damage one. In the case of elasto-plasticity, a linear Drucker-Prager criterion with a non-associated flow rule was defined in the compressive regime and a Rankine criterion with an associated flow rule was adopted in the tensile regime [1]. In the case of a damage model, the degradation of the material due to micro-cracking was described with a single scalar damage parameter [2]. Different formulations to describe the equivalent strain measure were taken into account. In addition, an anisotropic smeared crack approach was used with fixed and rotating cracks [3]. To properly describe strain localization, all models were enhanced by a characteristic length of micro-structure with the aid of a non-local theory [1], [2], [3]. The initial tensile strength was assumed to be uniform or stochastically distributed using spatially correlated random fields [4]. Truncated Gaussian random fields of the tensile strength were generated using a conditional rejection method [5] for correlated random fields. Plane strain calculations were performed for uniaxial compression and tension, bending with symmetric and nonsymmetric loading [6] and combined shear and extension [7].

The calculated results within a continuum mechanics were compared with a discrete approach using cohesive elements [8]. These elements are defined at the interface between standard elements to nucleate cracks and propagate them following the deformation process. They govern the separation of crack flanks in accordance with irreversible cohesive law. A simple class of mixed-mode cohesive laws was used accounting for tension-shear coupling obtained by introduction of an effective opening displacement (including the normal opening displacement and sliding displacement). The parameter assigning different weights to the sliding and normal opening displacement was taken into account. The cohesive surfaces were assumed to unload to the origin.

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